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METHODS FOR OBTAINING WATER FROM THE ATMOSPHERE IN ARID LANDS

By Giorgio NEBBIA,
Istituto Merceologia Università
Bari, Italy

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METHODS FOR OBTAINING WATER FROM THE ATMOSPHERE IN ARID LANDS

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Giorgio NEBBIA

Instituto Merceologia Universitá

Bari, Italy

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1. The main approach to the problem of obtaining fresh water, mainly for domestic uses, in the arid lands is given - if no other source of water is available - by the demineralization of saline waters which are often available in such lands. Some important steps have been made for the solution of this problem and it is reasonable to believe that plants having capacities of thousends cubic meters per day will spread in the near future. The solution for particular conditions may be given by the use of solar energy and the problem is discussed elsewhere in this conference.

2. In the present paper a different approach will be indicated. The atmosphere is an enormous source of water which is present as vapor mixed with the gases of the atmosphere itself. The amount of water per cubic meter of air depends on the air temperature and renges - at the saturation - from about 8 gr/m^3 at 10°C to about 50 gr/m^3 at 40°C. The specific weight of humid air is less than that of dry air at the same temperature and this causes humid air to lift to the higher layers of the atmosphere.

3. The present psper discusses the problem of obtaining water from the atmosphere. Water condenses out of the atmosphere if the air temperature decreases because the amount of water which can be mixed with the other gases decreases.

4. The problem of obtaining water from the atmosphere is far from having been fully investigated: there are several approaches which can be summarized as follows:

a) Natural condensation of water from the air occurs when, during the night, a strong cooling of the ground surface takes place, generally because of nocturnal radiation from the warm earth to the clear night sky. There are several places on the Earth where this natural condensation occurs or seems to occur. The strong nocturnal radiation apparently depends on the structure of the ground.

b) Natural condensation of water occurs when air is forced in artificial devices in which some cooling takes place. This seems to have been a source of water in some ancient towns. A review of this phenomenom has appeared in the literature (2) (3) but its reproduction on a large scale has not so far been possible. It is also possible, although difficult, to obtain water condensation through artificial devices which radiate heat during the night. The knowledge on the nocturnal radiation and on the best radiating materials is still scarce. It must be noted, however, that in order to obtain appreciable amounts of water the air must have a high relative humidity and that the humid air is scarcely transparent to the heat radiation emitted by a body having a temperature of about 20 to 40°C; such body emits towards the nocturnal sky a radiation having a wave length in the range of 9 - 12 ft. On the contrary, if the air is dry a rather high heat radiation is possible but the condensation hardly

occurs. Some experimental work has recently been carried in Chile on this line (4) but a very poor condensation has been observed.

c) The condensation of water can be obtained by cooling air below its dew-point. The minimum theoretical energy consumption is given by the latent heat of vaporization, namely about 600 kcal/kg. of condensed water.

5. For the energy balance of this last method let us assume to use a refrigerating machine operated by a mechanical compressor and that the "figure of merit" (ratio of heat shifted by the engine to heat represented by the power input) of the machine is as favourable as 5 to 1. For such machine the energy consumption of the process would be about 120 kcal/kg (0.14 kwh/kg) of condensed water. If the compressor were driven by a Diesel engine using a fuel with a calorific value of 10,500 kcal/kg and with a yield of 33%, a 1 HP refrigerating machine would require $\frac{640}{0.33 \times 10,500} =$ 0.180 kg of fuel to obtain 5.3 kg of water per hour. In other words, 1 kg of fuel would give about 30 liters of water.

6. Wind energy seems attractive as a source of mechanical energy for operating a refrigerating machine. The Enfield Andreu wind motor should be considered with interest for this purpose (5).

7. Absorption refrigerators might also be used. If a fuel were burnt directly in a thermally actuated refrigerant machine the yield might be a little greater than if it were burnt in a Diesel engine driving a mechanical compressor. Solar energy might be used as a source of heat (6).

8. The above points show that the problem is attractive but that many variables must still be evaluated. In order to give a contribution to the problem of obtaining water from the air by cooling some experimental work has been carried using an electrically operated mechanical dehumidifier (7).

9. In the experimental unit the external air is caused by a fan to enter the air duct, having a section of 24 cm x 20 cm. The air flows on the evaporator coil, perpendicular to the air flow; the air is thus cooled below its dew point and water condenses on the evaporator surface. The cool saturated air then flows on the condenser coil, parallel to the evaporator coil and at a distance of about 5 cm. The dehumidified air is then discharged. The power of the unit is about 1/8 HP (about 95 watt); the actual energy consumption and the conditions of the inlet air have been measured and correlated with the amount of condensed water.

10. During a work extended for about one year in Bari, on the roof of a building near the sea, the following results have been obtained:

a) The electric energy consumption of the device was about 110 ♦ 10 watt-hours/hour and was independent from the amount of separated water.

b) The amount of water separated from the air depends on the physical conditions of the air itself; the water production paralleled the values of the relative humidity.

c) With the particular experimental unit used in this work, water condensation is observed when the relative humidity is more than 50%, independently from the dry-bulb air temperature.

d) Usually the amount of water recovered from the air was about 10 to 20 liters per week, the specific energy consumption being in most weeks 1000 to 1500 kcal/liter of condensed water.

e) The electric energy consumption per weight unit of separated water has been, in the best conditions, 1.5 - 2 times the latent heat of condensation of water, therefore several times larger than the mimimum theoretical energy consumption, due to the

latent heat only, in the most favourable mechanical devices, namely 120 kcal/liter of water. The larger energy consumption is due to the poor heat exchange between the cool air, at the outlet of the evaporator coil, and the surface of the condenser coil of the refrigerating machine. In the little dehumidifiers, (1/8 to 1 HP), in fact, the air speed is rather high, of the order of 200-400 m^3/hour, and such speeds do not allow a good heat exchange and a good recovery of the sensible heat.

f) When the dry-bulb temperature of the inlet air is lower than 10°C, ice formation is observed on the surface of the evaporator coil.

11. The present results suggest some consideretions:

a) The energy consumption in the extraction of water from the atmosphere is such that it does not seem convenient to use this method for obtaining large amounts of water in the arid lands.

b) In emergency conditions, when rather limited amounts of water are needed for the survival of families or groups of persons in arid lands and no source of water at all is available, the extraction of water from the atmosphere may be used if rather high values of relative humidity are observed, at least in some hours of the day.

c) The experimental results suggest the design of more efficient devices for condensing water from the atmosphere; such new devices should have a very good heat exchange and recovery of sensible heat from the dehumidified air.

d) Studies must be carried on the use of wast energy (e.g. of the extra energy of motor cars) for operating mechanical dehumidifiers, and on the use of wind energy, which is directly a source of mechanical energy and which brings the air on the cooling elements of the wind-driven refrigerating machines seems attractive as a system for using heat for cooling air and separating water.

e) Considerable more researches are needed for a better understanding of the phenomena related to natural water condensation after cooling of the air through nocturnal radiation or artificial devices; from such basic studies it is possible to develop practical systems for the production of water for the arid lands.

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1692 E - Nov.1962 - 1,600